AZ–EL USB ROTOR CONTROLER
AE-21
User Manual

FEATURES

- **Azimuth / Elevation point and shot control**
- **Graphic 2.7” OLED display 128x64 pixels**
- **Soft ramp-up and ramp-down AC motor control**
- **8 outputs for antenna control**
- **8 antenna / offset configurations**
- **USB serial interface**
- **Yaesu GS-232A commands compatible for computer control**
- **Compatible with Yaesu G-5500, G-450, G-650, HY-Gain and other AC motor rotors**
- **Solid-state relays for quiet and reliable operation**
- **Brake control with programmable delay**
- **Small footprint W=130mm x H=58mm x D=190mm**

1 Front Panel Display and Controls

The front panel includes a graphical 128x64 pixel OLED display and two dial encoders with push buttons, labeled **AZ** (top) and **EL** (bottom).

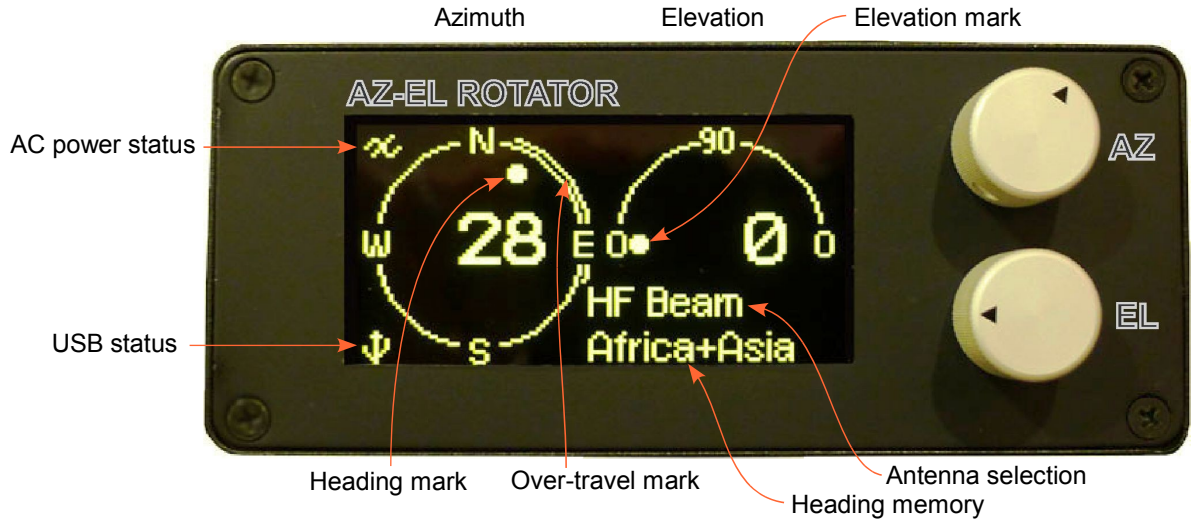


Figure 1: AE-21 Front panel view

- **Azimuth** — displays current antenna heading in degrees when stopped or moving. Will display the new target heading when dialing with the **AZ** knob.
- **Heading mark** — Full circle ● shows current azimuth heading when stopped. Circle ○ shows current azimuth heading when moving. Target symbol ✛ shows target heading when dialing or moving.
- **Over-travel mark** — Indicates more than 360° travel and overlap range.
- **Antenna selection** — Displays the name of current antenna offset selection. There are 8 user configurable antenna offset combinations.
- **Heading memory** — Shows heading memory text, corresponding to displayed azimuth.
- **Elevation** — Displays antenna elevation in degrees when stopped or moving. Will display the new target elevation when dialing with the **EL** knob.
- **Elevation mark** — Full circle ● shows current elevation when stopped. Circle ○ shows current elevation when moving. Target symbol ✛ shows target elevation when dialing or moving.
- **AC voltage status** — Symbol is displayed when there is no AC power present or the internal timing is not synchronized to the AC power phase.
- **USB status** — Displayed when connected to USB port and ready to communicate.

The **AZ** dial is used to enter new target heading or changing the antenna offset selection.
Turning the **AZ** dial will change **Heading mark** symbol to + and display the new dialed heading target degrees. **Heading memory** will follow**.** Note that the encoder resolution changes with dialing speed. When moved slowly, target heading can be selected with 1º increments. Turn it faster for larger changes. Dialing will be limited to CCW / CW antenna travel limits.

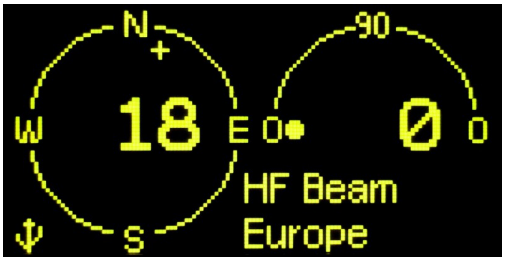


Figure 2: Dialing new target

AE-21 starts rotor movement automatically, following the dialed new heading target. When rotor is moving and the new heading target is in opposite direction, it will be ramped-down to complete stop, then ramped-up in opposite direction.

Figure 3: Moving to target

After 2 seconds of dial inactivity, the display will show the current antenna heading moving to target.
A short tap on **AZ** button will ramp-down and stop azimuth rotor motion.

The **EL** dial is used to enter new target elevation or changing the display settings.
Entering new elevation target is done in the same manner - just dial new elevation target and rotor will follow.
A short tap on **EL** button will ramp-down and stop elevation rotor motion.

To select different antenna offset, press and hold down the **AZ** button until **Antenna selection** is displayed inverse.

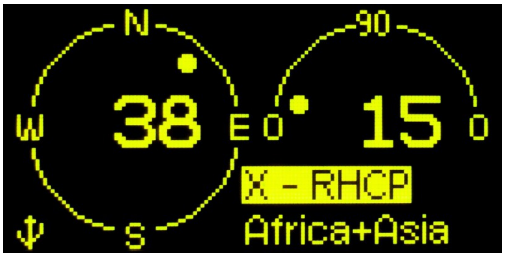


Figure 4: Selecting antenna / offset

Use the dial to move through the list of defined antenna offset settings. Antenna bearing and outputs will be updated while scrolling. There two ways to exit this mode:

- A short tap on **AZ** button will exit this mode immediately. If this new selection has a different offset, motion will be started to compensate it. Second short tap on **AZ** button will stop azimuth motion.
- Stop dialing for >2 seconds and selection mode will be timed-out without starting a motion.

To change display settings, press and hold down the EL button until **Power OFF** is displayed inverse. Use the dial to adjust the display settings **Power OFF** → **Dim** → **Normal** → **Bright.** Short tap or stop dialing for >2 seconds to exit this selection mode.

Figure 5: Selecting display power settings

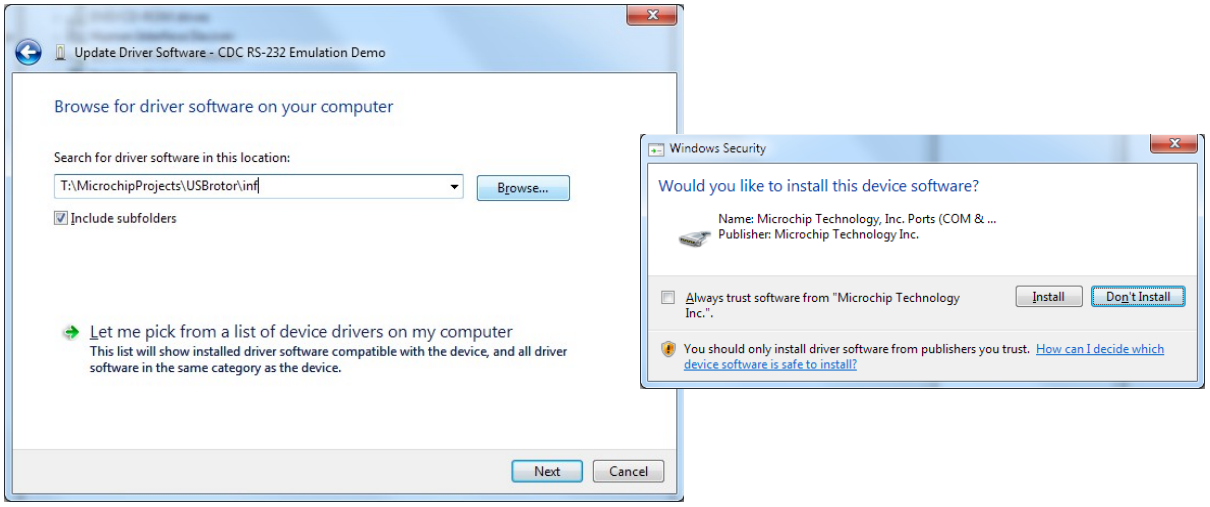
Power OFF selection will turn the display off and disable front panel controls. USB control will remain functional. To restore display and manual operation, press and hold the **EL** button for >2 seconds or send !`disp 2` command.

2 USB Interface

When connected to a computer USB port, AE-21 will be recognized and enumerated as a standard USB virtual serial COM port and it can be used for:

- Rotor controller calibrating and tuning.
- Automated azimuth / elevation control. Need to be connected to AC power.
- Antenna selecting and outputs switching.
- User parameters backup / restore.
- Firmware update.

If the host is a PC and this is the first time you have plugged this device into the computer, then you may be asked for a new driver (mchpcdc.inf) file. Select the “Browse my computer for driver software” option. Navigate to the directory containing the file, then click next. Click install.


Update Driver Software - CDC RS-232 Emulation Demo
Browse for driver software on your computer
Search for driver software in this location:
T:\MicrochipProjects\USBrotor\inf
Browse...
Include subfolders
Let me pick from a list of device drivers on my computer
This list will show installed driver software compatible with the device, and all driver software in the same category as the device.
Next
Cancel
Windows Security
Would you like to install this device software?
Name: Microchip Technology, Inc. Ports (COM & ...
Publisher: Microchip Technology Inc.
Always trust software from "Microchip Technology Inc.".
Install
Don't Install
You should only install driver software from publishers you trust. How can I decide which device software is safe to install?

Once the device is successfully installed, open up a terminal program, such as Putty or Hyperterminal. Select the appropriate COM port for the USB virtual COM port. On most machines this will be COM5 or higher. AE-21 will operate with any combinations of Baud rate, Data bits and Parity settings. Set your terminal to emulate VT100 so you can use these keys:

- Up-arrow repeat or edit last command
- Left / Right arrow move cursor left / right
- Backspase delete one character

A subset of Yaesu GS-232A control interface commands are supported for compatibility with existing tracking software. All other AE-21 specific commands begin with the exclamation point **!** symbol. See chapter 6 for command description. Commands needs to be terminated with carriage return (ASCII 13) symbol.

On a new line, type the following command and press enter:

ver↵

The controller should respond with its type, serial number and firmware version

>AE-21 rotor controller SN:001002, ver:1.2/1.0

By default characters, echo is turned off to comply with GS-232A protocol. Echo can be turned on in terminal program or with *!echo 7* command.

3 Installation

Connectors are located on AE-21 back panel.

- Ground terminal with 6/32 (M4) tread. Connect to the station ground.
- Standard IEC 60320-1 C14 power inlet.
  Power transformer is wired internally for 115VAC or 230VAC
  Check your wiring for correct AC voltage before plugging.
- USB-B connector. Optional connection to PC for automated control or firmware upgrade.
- Three 8 position terminal blocks are used to connect AZ - EL rotors and user Outputs.
  Push the button with small screwdriver to install or remove wire.
  Recommended are 18AWG - 22AWG wire sizes.

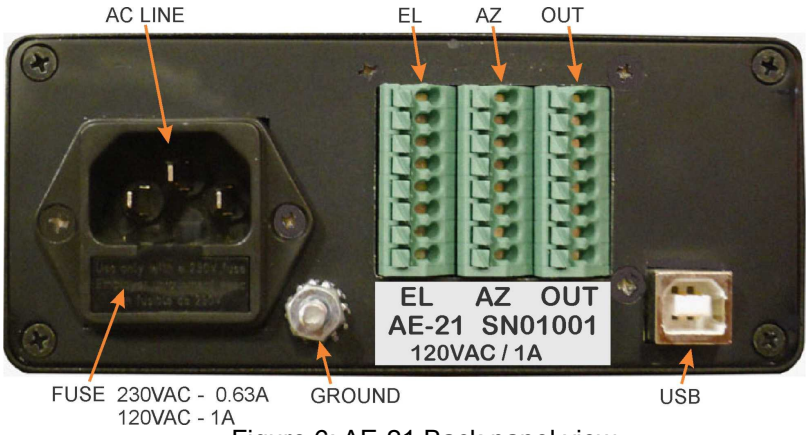


Figure 6: AE-21 Back panel view

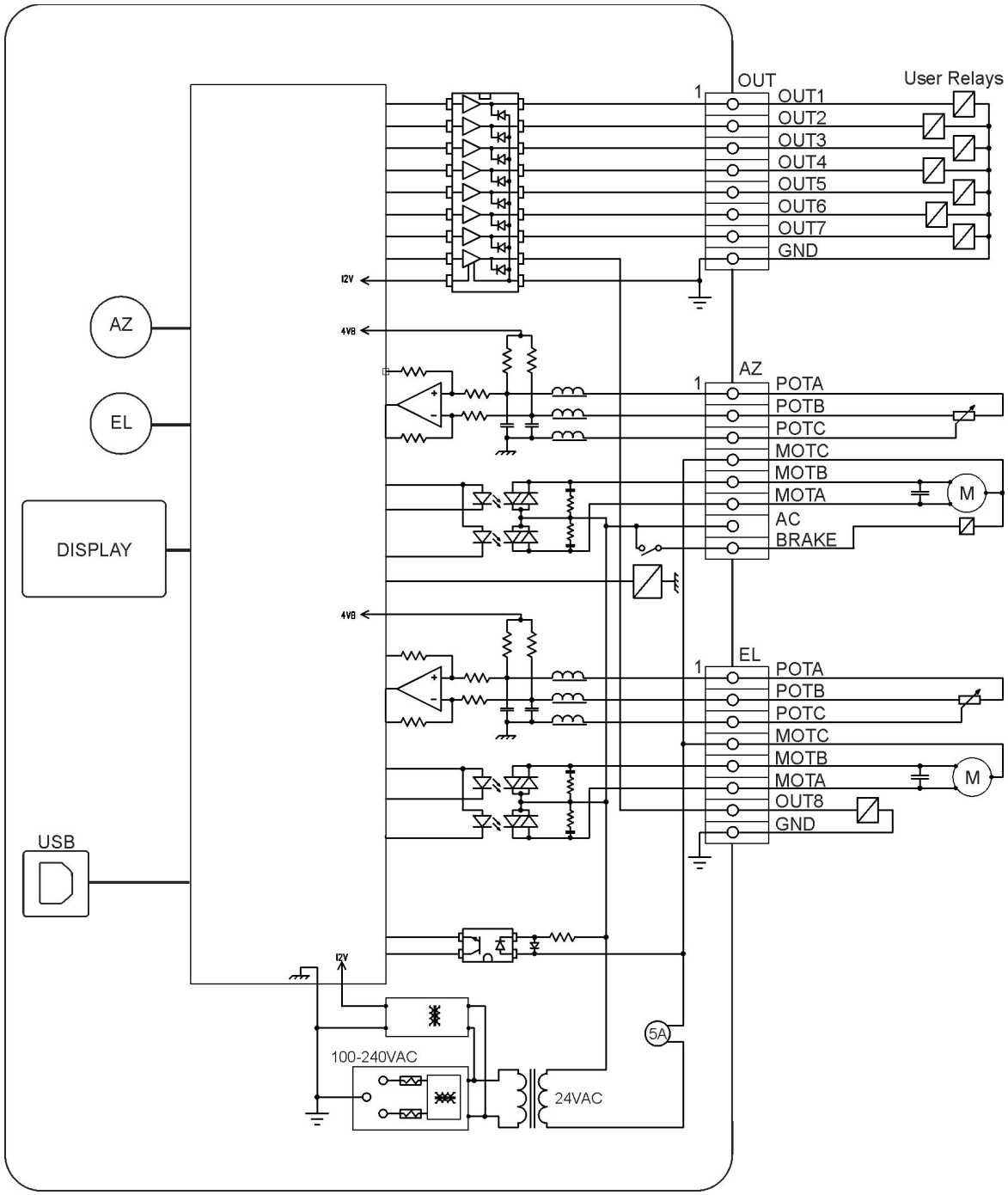


Figure 7: Wiring Diagram

Note that Yaesu rotors have the motor starting capacitor integrated inside.
For HY-Gain or other AC motor rotors, external motor starting capacitor needs to be installed.

Elevation rotor wiring for Yaesu G-5500

	EL	G-5500	Description	Wire color
1	POTA	E1	Potentiometer feedback – A	
2	POTB	E3	Potentiometer feedback – B	
3	POTC	E2	Potentiometer feedback - Wiper	
4	MOTC	E6	Motor common point	
5	MOTB	E4	Motor winding - CCW	
6	MOTA	E5	Motor winding - CW	
7	OUT8	-	Output 12VDC/0.1A	
8	GND	-	Ground	

Azimuth rotor wiring for Yaesu G-5500

	AZ	G-5500	Description	Wire color
1	POTA	A1	Potentiometer feedback – A	
2	POTB	A3	Potentiometer feedback – B	
3	POTC	A2	Potentiometer feedback - Wiper	
4	MOTC	A6	Motor common point	
5	MOTB	A4	Motor winding - CCW	
6	MOTA	A5	Motor winding - CW	
7	AC	-	24VAC	
8	BRAKE	-	Optional brake 24VAC / 0.5A	

Outputs wiring

	OUT	Description	Wire color
1	OUT1	Output 12VDC/0.1A	
2	OUT2	Output 12VDC/0.1A	
3	OUT3	Output 12VDC/0.1A	
4	OUT4	Output 12VDC/0.1A	
5	OUT5	Output 12VDC/0.1A	
6	OUT6	Output 12VDC/0.1A	
7	OUT7	Output 12VDC/0.1A	
8	GND	Ground	

4 Azimuth / Elevation Calibration

First, restore default settings for azimuth rotor by sending:

```
!az cal res↵            ;restore AZ factory default parameters
```

// speed 70/50 decel point ??.. offset =0 antsel =1//

This command will not change parameters in NV memory until they are saved with `!save` command.

Check rotation direction by sending “rotate CW” command:

```
!az +↵                  ;starting movement in CW direction
```

Rotation can be stopped anytime by shortly tapping AZ dial or with stop command:

```
s↵                      ;stop now
```

Rotor should rotate CW (N → E → S → W). Azimuth degrees on display should increase.
If rotor is rotating in opposite direction, exchange MOTA and MOTB wires and check again.
If display degrees are decreasing, exchange POTA and POTB wires and check again.

Check rotation direction by sending “rotate CCW” command:

```
!az -↵                  ;starting movement in CCW direction
```

Rotate fully CCW to rotor hard stop or until some other limitation is reached.

```
!az -↵                  ;starting movement in CCW direction
s↵                      ;stop now
```

After rotor was stopped, set the rotor zero position and CCW soft limit with:

```
!az cal ccw↵            ;set most CCW point and CCW limit
```

Now rotate fully CW to rotor hard stop or until some other limitation is reached.

```
!az +↵                  ;starting movement in CW direction
s↵                      ;stop now or tap AZ button
```

After rotor is stopped, set the rotor CW soft limit and calibrate rotor feedback with:

```
!az cal cw↵             ;set most CW point and CW limit
```

If the rotation angle between CCW and CW points was not exactly 360° full circle, specify it.
For example for Yaesu G-450, full CCW to CW rotation is about 450° with 90° overlap.

```
!az cal cw 450↵         ;set most CW point and CW limit. 90deg overlap!
```

Now the rotor is calibrated. Verify the rotor and display operation by turning it at different angles. Display shows the rotor angle in 0° – 359° interval and overlapping range.

```
!az 270↵                ;Goto 270deg
```

```
!az 180↵              ;Goto 180deg

!az 90↵               ;Goto 90deg

!az 0↵                ;Goto 0deg

!az 350↵              ;Goto 350deg
```

Last command will rotate just 10° CCW if rotor was calibrated with overlap by using the shortest path.
If everything looks fine, read calibration settings and copy / paste them to a text editor for backup.

```
!az cal↵
>!az cal xx xx xx xx xx          ;copy this line and paste it for backup
```

Save all changes to the NV memory:

```
!save↵
```

Rotor can be installed with any stop direction and then an antenna offset can be specified. Currently, offset is set to zero and the rotor position is displayed.
Actual antenna bearing is calculated by adding antenna specific offset (*display* = *rotor_deg* + *offset*). Up to 8 different antenna offsets can be specified and selected with front panel controls or serial port. Antenna offset is the difference between antenna bearing and rotor “zero” position (*offset* = *display* – *rotor_deg*).
Following example is for one HF beam mounted with 165° offset (south stop). VHF/UHF cross Yagi system with elevation control is mounted at 75° offset so they can slide between HF beam elements and minimize interaction. Rotor outputs Out3 and Out2 are used to switch VHF/UHF cross Yagi polarization. Out1 is used to switch between HF beam and additional Windom antenna.

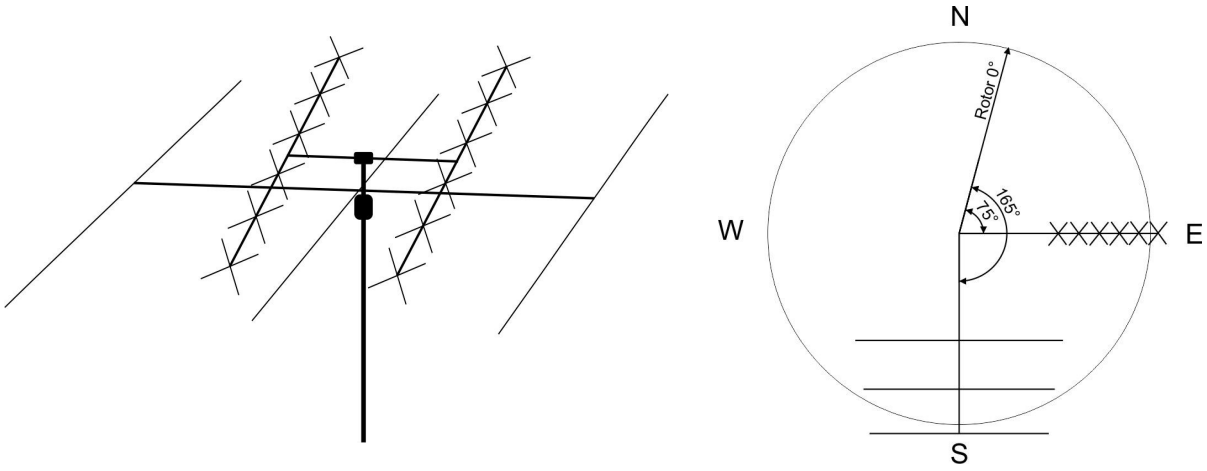


Figure 8: Sample configuration - HF beam and VHF/UHF cross Yagi

This configuration can be set with the following commands:

```
!az o 1 165 XXXXXXX0 Windom↵      ;Ant#1 Windom, Out1=0
!az o 2 165 XXXXXXX1 HF beam↵     ;Ant#2 HF beam, Out1=1
!az o 5 75 XXXXX00X X-VPOL↵       ;Ant#5 X-Yagi Vertical polarization
!az o 6 75 XXXXX11X X-HPOL↵       ;Ant#6 X-Yagi Horizontal polarization
!az o 7 75 XXXXX01X X-LHCP↵       ;Ant#7 X-Yagi Lefthand circular polarization
!az o 8 75 XXXXX10X X-RHCP↵       ;Ant#8 X-Yagi Righthand circular polarization
```

Check your settings with:

```
!az o↵

!az o 1 165 XXXXXXX0 Windom
!az o 2 165 XXXXXXX1 HF beam
!az o 5 75 XXXXX00X X-VPOL
!az o 6 75 XXXXX11X X-HPOL
!az o 7 75 XXXXX01X X-LHCP
!az o 8 75 XXXXX10X X-RHCP
```

Copy / paste answers to a text editor for backup.
Check all settings by switching between antennas. Press and hold down the **AZ** button until **Antenna selection** is displayed inverse, then rotate it to move through the list of defined antenna/offset settings. Alternatively using the terminal:

```
!az a 5↵                    ;Select antenna/offset #5
```

Save all changes to the NV memory:

```
!save↵
```

Elevation rotor calibration.
First restore factory defaults for G-550 by sending:

```
!el cal res↵
```

// speed 70/50 decel point ??.. offset =0 antsel =1//

Check rotation direction by sending “rotate UP” command:

```
!el +↵                      ;start up movement
```

Rotation can be stopped anytime by shortly tapping EL dial or with stop command:

```
s↵                          ;stop now
```

If rotor is rotating in opposite direction, exchange MOTA and MOTB wires and check again.
If display degrees are decreasing, exchange POTA and POTB wires and check again.

Check rotation direction by sending “rotate DOWN” command:

```
!el -↵                      ;start down movement
```

Now rotate down until hard stop or some other limitation is reached.

```
!el -↵                      ;start down movement
s↵                          ;stop now or tap EL button
```

After rotor has stopped, set the elevation rotor zero position and limit with:

```
!el cal neg↵                ;set most negative point / limit
```

Now rotate in positive direction until rotor hard stop or some other limitation is reached.

```
!el +↵                      ;start up movement
s↵                          ;stop now or tap EL button
```

After rotor was stopped, set the elevation rotor most positive position and calibrate rotor feedback with:

```
!el cal pos↵                ;set most positive point / limit
```

If the rotation angle was not exactly 180° specify it:

```
!el cal pos 87↵             ;set most positive point/limit with 87deg travel
```

Now the elevation rotor is calibrated. Verify the rotor and display operation by turning it at different angles. Display shows the rotor angle in 0° to +/-180° interval.

```
!el 70↵                     ;Goto 70deg

!el 0↵                      ;Goto 0deg
```

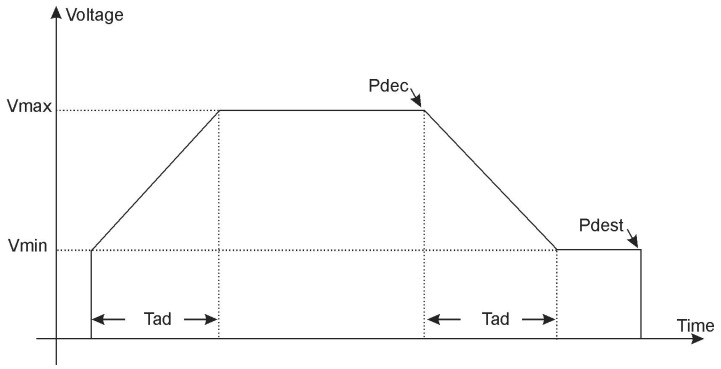
Antenna elevation offset can be specified to compensate any difference between antenna elevation and displayed elevation.

```
!el o 7↵                    ;set elevation offset to 7deg
```

Display shows the rotor angle in 0° to +/-180° interval.

5 Tuning

AE-21 rotor controller uses phase modulation to regulate the voltage applied to the motor.
Motion starts with the requested minimum voltage (Vmin), increasing for defined time (Tad) to requested maximum voltage (Vmax). Ramp-down will start at deceleration point (Pdec). Motor voltage will be decreased to Vmin and rotor will creep to the destination point (Pdest).



Values of the Vmin and Vmax will change with motor cable length and load. This fine tuning should be done after complete rotor and antenna Installation.
First, find the minimum voltage needed to turn the rotor. Start with low value for Vmax and increase it until rotor starts turning. Rotation can be stopped anytime by shortly tapping AZ dial or with stop command.

```
!az + 30 10 2000↵            ;CW direction, Vmax=30%, Vmin=10%, Tad=2sec

!az + 35 10 2000↵

!az + 40 10 2000↵            ;rotor starts moving

!az - 40 10 2000↵            ;check also the negative direction

s↵                           ;stop now
```

Continue to increase Vmax until rotor starts to move with its maximum speed. For Vmin, use the previously found value. This is best done in a start–stop sequence.

```
!az + 50 40 2000↵            ;CW direction, Vmax=50%, Vmin=40%, Tad=2sec

s↵                           ;wait to accelerate and stop

!az + 60 40 2000↵            ;CW direction, Vmax=50%, Vmin=40%, Tad=2sec

s↵                           ;wait to accelerate and stop
```

Usually, Vmax should be no more than double the value of Vmin. Going higher will be just more wasted power and heat on the motor.

Ramp-up / ramp-down can be disabled by setting Vmin = Vmax and Tad=0.

To find Pdec point, request rotor to go at specific target far enough to accelerate and move with Vmax. Use the previously optimized values for Vmax, Vmin and Tad.

```
!az 300 60 40 2000 0↵        ;goto 300° Vmax=60%, Vmin=40%, Tad=2sec, Pdec=0
```

Rotor will begin deceleration when it has reached 300° and will then ramp-down to stop some degrees after the target. Set Pdec to the difference between requested target and actual rotor stop. In this example, if rotor stopped at 307°, try Pdec=8 to give it room to decelerate and creep to target.

```
!az 200 60 40 2000 8↵          ;goto 200° Vmax=60%, Vmin=40%, Tad=2sec, Pdec=8
```

Additionally, two time-out parameters can be specified to help protect the motor from overheating.
In case of feedback failure or mechanically stalled rotor, power to the motor will be shut-down after MoveTimeout seconds.
Chose MoveTimeout to be little longer than one full rotation time – 100sec is enough for most cases.
StopTimeout is used to prevent endless rotor creeping to target after ramp-down – 5sec is good for most cases.
BrakeDelay is the brake engage delay time after motor is stopped – 3 sec is good for most cases.

Finally, set the optimized values as default for all future commands:

```
!az p 60 40 2000 8 100 5 3↵    ;Vmax=60%, Vmin=40%, Tad=2sec, Pdec=8
                               ;MoveTimeout=100, StopTimeout=5, BrakeDelay=3
```

And save all changes to the NV memory:

```
!save↵
```

6 Terminal Commands Description

Commands begin on a new line and can have up to 9 parameters separated with space (ASCII 32).
Parameters in square brackets `[]` are optional, and all previous parameters need to be entered.
A subset of Yaesu GS-232A control interface commands are supported for compatibility with existing tracking software. All extended AE-21 specific commands begin with the exclamation point **!** symbol.

6.1 Yaesu GS-232A commands

The first letter can be upper or lower case. For compatibility, prompt is not returned. Invalid commands or parameters will cause “?>” to be returned. Note that echo must be set to OFF before starting your tracking software. See GS-232A user manual for more details.

All Stop

`S↵`

Ramp-down and stop both azimuth and elevation motors.

Turn to azimuth

`Maaa↵`

Parameters:

aaa – azimuth 0..450deg

Turn to azimuth and elevation

Waaa eee↵

Parameters:

aaa – azimuth 0..450deg
eee – elevation 0..180deg

Return current azimuth

C↵
+0351

Returns current azimuth angle in format +0000..+0359 deg

Return current azimuth and elevation

C2↵
+0351+0056

Returns current azimuth angle in format +0000..+0359deg, followed by elevation +0000..+0180deg

6.2 Configuration commands

Set terminal echo mode

Used to set echo mode. When used with tracking software, echo must be turned off for compatibility.

!echo n↵
>

Parameters:

n – terminal echo mode:
0 – no echo. GS-232A compatible mode. Power-up default.
1 – echo back all characters
7 – echo back all characters and add LF after CR

Set AC line frequency

Enter 50 or 60 to specify local AC power line frequency.
Factory defaults loaded with *!az cal res* are for 60Hz.

!acfreq 50↵
>

6.3 Azimuth control

Read Azimuth heading and status

!az↵
nnn 0xssss
>

Returns:

nnn – current azimuth in 0 to 359 degrees

0xssss – azimuth status in 16bit HEX format

bit2..0 – 3bit Motor State. Valid states are:

0 – idle - motor is not moving
1 – start motion
2 – ramp-up
3 – moving with Vmax
4 – ramp-down
5 – creep to target with Vmin
6 – brake delay

bit3 – Direction

0 – positive
1 – negative

bit4 – Over-travel

0 – current heading is in 0-359deg range
1 – current heading is > 360deg range

bit5 – Target mode

0 – rotating in jog mode, until stopped
1 – rotating to specified target

bit6 – Brake status

0 – Brake is engaged (relay is OFF)
1 – Brake is released (relay is ON)

bit7 – Reserved

bit8 – CCW Limit

Set when CCW limit is reached. Rotor can be moved only in CW direction.

bit9 – CW Limit

Set when CW limit is reached. Rotor can be moved only in CCW direction.

bit10 – TimeOut

Set when MoveTimeout or StopTimeout expired.
Cleared when new motion is requested.

bit11 – ACstatus

0 – AC power not present or the internal timing is not synchronized to the AC power phase. AZ and EL motors can't be rotated.
1 – AC power is present and motors are ready to move.

bit15..12 - Reserved

Azimuth Rotate

Rotate in positive direction – jog mode

```
------
!az +[Vmax] [Vmin] [Tad] [Pdec]↵
>
------
```

Rotate in negative direction – jog mode

```
------
!az -[Vmax] [Vmin] [Tad] [Pdec]↵
>
------
```

Rotate to specific heading – target mode

```
------
!az ttt [Vmax] [Vmin] [Tad] [Pdec]↵
>
------
```

Parameters:

ttt	– azimuth target in degrees 0..359
Vmax	– requested maximum voltage 1..100%
Vmin	– requested minimum voltage 1..100%
Tad	– ramp-up / ramp-down time 0..30 000mSec
Pdec	– ramp-down deceleration point 0..255deg before reaching target point Pdest

Azimuth stop

Ramp-down and stop azimuth rotation now

```
------
!az s↵
>
------
```

Azimuth antenna offset configuration set / display

Set antenna offset configuration.

```
------
!az o n offset outputs text↵
>
------
```

Parameters:

n	– antenna offset number 1..8
offset	– antenna offset from -359..+359 degrees
outputs	– rotor outputs settings. X= don't change. 0= turn OFF. 1= Turn ON. 1XXXXXX0 means Out8 = ON, Out1 = OFF, all other don't change. All 8 bit must be specified.
text	– antenna selection text to be displayed

Read current offset settings.

```
------
!az o↵

!az o 1 165 XXXXXXX0 Windom
!az o 2 165 XXXXXXX1 HF beam
!az o 5 75 XXXXX00X X-VPOL
!az o 6 75 XXXXX11X X-HPOL
!az o 7 75 XXXXX01X X-LHCP
!az o 8 75 XXXXX10X X-RHCP
>
------
```

Prints list of the current antenna offset configuration.
Copy this response from terminal window for backup and restore purposes.

Azimuth Antenna offset select / display

Read antenna selected.

```
------
!az a n↵
>
------
```

Parameters:

`n` – antenna offset number 1..8

Read antenna selected .

```
------
!az a↵
1
>
------
```

Read currently selected antenna offset.
After power-up antenna offset 1 is selected.

Azimuth Parameters set / display

Set azimuth default parameters

```
------
!az p [Vmax] [Vmin] [Tad] [Pdec] [MoveTimeout] [StopTimeout] [BrakeDelay]↵
>
------
```

Parameters:

`Vmax`	– requested maximum voltage 1..100%	(70%)
`Vmin`	– requested minimum voltage 1..100%	(50%)
`Tad`	– ramp-up / ramp-down time 0..30 000ms	(2000ms)
`Pdec`	– ramp-down deceleration point 0..255deg before reaching target point	(5deg)
`MoveTimeout`	– maximum 1..255s time for movement in single command	(100s)
`StopTimeout`	– maximum 1..255s time to creep	(5s)
`BrakeDelay`	– delay in 0..255s after motor stop to brake engage	(30s)

Note: Values in () are factory defaults values loaded with *!`az cal res`* command.

Read azimuth default parameters

```
!az p↵
!az p 70 50 2000 5 100 5 30
>
```

Azimuth calibration set / display

Restore and print azimuth factory default parameters for Yaesu G-5500 or G-450

```
!az cal res↵
Factory defaults loaded.
!az cal set 0 450 56 2.563889
>
```

Set and print azimuth calibration parameters

```
!az cal set CCWlimit CWlimit ADCoffset AZtoADC↵
!az cal set 0 450 56 2.563889
>
```

Parameters:

`CCWlimit`	– CCW travel limit 0..359deg	(0)
`CWlimit`	– CW travel limit 0..719deg	(449)
`ADCoffset`	– potentiometer fedback offset value 0..1023	(56)
`AZtoADC`	– decimal divisor used to calculate rotor position >0	(2.563889)

Note: Values in () are factory defaults values loaded with *!az cal res* command.

Read current azimuth calibration parameters

```
!az cal↵
!az cal set 0 450 56 2.563889
>
```

Set current rotor position as CCW limit point

```
!az cal ccw↵
>
```

Set current rotor position as CW limit point and calculates ADCoffset and AZtoADC feedback parameters. Will print calculated values for reference.

```
!az cal cw [deg]↵
!az cal set 0 450 56 2.563889
>
```

Parameters:

`deg` - distance between CCW and CW limits in 0..360deg

6.4 Elevation control

Read Elevation and status

!el↵
nnn 0xssss
>

Returns:
nnn – current elevation in -180 to +180 degrees
0xssss – elevation status in 16bit HEX format
bit2..0 – 3bit Motor State. Valid states are:
0 – idle - motor is not moving
1 – start motion
2 – ramp-up
3 – moving with Vmax
4 – ramp-down
5 – creep to target with Vmin
bit3 – Direction
0 – up / positive
1 – down / negative
bit4 – Reserved
bit5 – Target mode
0 – rotating in jog mode, until stopped
1 – rotating to specified target
bit6 – Reserved
bit7 – Reserved
bit8 – NEG Limit
Set when negative limit reached. Rotor can be moved only in positive direction.
bit9 – POS Limit
Set when positive limit reached. Rotor can be moved only in negative direction.
bit10 – TimeOut
Set when MoveTimeout or StopTimeout expired.
Cleared when new motion is requested.
bit11 – ACstatus
0 – AC power not present or the internal timing is not synchronized to the AC power phase.
AZ and EL motors can't be rotated.
1 – AC power is present and motors are ready to move.
bit15..12 – Reserved

Elevation Rotate

Rotate in positive direction – jog mode

!el +[Vmax] [Vmin] [Tad] [Pdec]↵
>

Rotate in negative direction – jog mode

!el -[Vmax] [Vmin] [Tad] [Pdec]↵
>

Rotate to specific elevation – target mode

```
------
!el ttt [Vmax] [Vmin] [Tad] [Pdec]↵
>
------
```

Parameters:

- *ttt* – elevation target in degrees -180..+180
- *Vmax* – requested maximum voltage 1..100%
- *Vmin* – requested minimum voltage 1..100%
- *Tad* – ramp-up / ramp-down time 0..30 000mSec
- *Pdec* – *ramp-down deceleration point 0..255deg before reaching target point (Pdest)*

Elevation stop

Ramp-down and stop elevation rotation now

```
------
!el s↵
>
------
```

Elevation antenna offset set / display

Set antenna elevation offset.

```
------
!el o offset↵
>
------
```

Parameters:

- offset – antenna offset from -180..+180 degrees

Read antenna elevation offset.

```
------
!el o↵
-20
>
------
```

Elevation Parameters set / display

Set elevation default parameters

```
------
!el p [Vmax] [Vmin] [Tad] [Pdec] [MoveTimeout] [StopTimeout]↵
>
------
```

Parameters:

Vmax	– requested maximum voltage 1..100%	(70%)
Vmin	– requested minimum voltage 1..100%	(50%)
Tad	– ramp-up / ramp-down time 0..30 000ms	(2000ms)
Pdec	– ramp-down deceleration point 0..255deg before reaching target point	(5deg)
MoveTimeout	– maximum 1..255s time for movement in single command	(100s)
StopTimeout	– maximum 1..255s time to creep	(5s)

Note: Values in () are factory defaults values loaded with *!el cal res* command.

Read elevation default parameters

```
------
!el p↵
!el p 70 50 2000 5 100 5
>
------
```

Elevation calibration set / display

Restore and print elevation factory default parameters for Yaesu G-5500

```
------
!el cal res↵
Factory defaults loaded.
!el cal set 0 180 58 4.978142
>
------
```

Set and print elevation calibration parameters

```
------
!el cal set NEGlimit POSlimit ADCoffset ELtoADC↵
!el cal set 0 180 58 4.978142
>
------
```

Parameters:

`NEGlimit`	– positive travel limit -180..+180deg	(0)
`POSlimit`	– negative travel limit -180..+180deg	(180)
`ADCoffset`	– potentiometer fedback offset value 0..1023	(58)
`ELtoADC`	– decimal divisor used to calculate rotor position >0	(4.978142)

Note: Values in () are factory defaults values loaded with *!el* `cal res` command.

Read current azimuth calibration parameters

```
------
!el cal↵
!el cal set 0 180 58 4.978142
>
------
```

Set current rotor position as negative limit point

```
------
!el cal neg↵
>
------
```

Set current rotor position as positive limit point and calculates ADCoffset and ELtoADC feedback parameters. Will print calculated values for reference.

```
------
!el cal pos [deg]↵
!el cal set 0 180 58 4.978142
>
------
```

Parameters:

`deg` - distance between NEG and POS limits in 0..360deg

6.5 Display Commands

First argument can be a numeric value used to set display state or a sub-command, followed by up to eight arguments.

Set display state

!disp n↵
>

Parameters:

n – set display state 0..255
- 0 – turn display and front controls OFF
- 1 – low display intensity – dimmed display
- 2 – normal display intensity
- 3 – bright display intensity
- 255 – stop display refresh and front controls but leave display on. Commands to print text and figures can be used.

Display and front controls set sub-command

!disp set stime ss [ws] [mtout] [bclick] [bpress]↵
>

Parameters:		Factory defaults
stime	– screen-saver timeout in 0..255sec. Enter 0 to disable.	(0sec)
ss	– screen-saver display state to enter after time-out	(0)
ws	– wake-up display state	(3)
mtout	– menu selection time-out 1..65535ms	(2000ms)
bclick	– button short click time 1..65535ms	(100ms)
bpress	– button long time 1..65535ms	(2000ms)

Clear display sub-command

!disp cls↵
>

Display text sub-command

!disp text c fnt x y string↵
>

Parameters:

c – color 0 → black, 1 → white

fnt – font number
- 1 – small letters 10 points
- 2 – big letters 16 points
- 3 – special symbols

x, y – x, y coordinates of the first letter lower left corner (0,0..127,63)

string – text string to be displayed

Draw pixel sub-command

!disp pix c x y↵
>

Parameters:

c	–	color 0 → black, 1 → white
x, y	–	pixel x, y coordinates

Draw line sub-command

!disp line c x1 y1 x2 y2↵
>

Parameters:

c	–	color 0 → black, 1 → white
x1, y1	–	start point coordinates (0,0..127,63)
x2, y2	–	end point coordinates (0,0..127,63)

Draw beveled figure sub-command

For a pure circular object x1 = x2 and y1 = y2. For a rectangular object radius = 0.

!disp bevel c x1 y1 x2 y2 rad↵
>

Parameters:

c	–	color 0 → black, 1 → white
x1, y1	–	coordinate of the upper left center of the circle that draws the rounded corners
x2, y2	–	coordinate of the upper left center of the circle that draws the rounded corners
rad	–	defines the radius of the circle, that draws the rounded corners

Draw filled beveled figure sub-command

For a pure circular object x1 = x2 and y1 = y2. For a rectangular object radius = 0.

!disp fbevel c x1 y1 x2 y2 rad↵
>

Parameters:

c	–	color 0 → black, 1 → white
x1, y1	–	coordinate of the upper left center of the circle that draws the rounded corners
x2, y2	–	coordinate of the upper left center of the circle that draws the rounded corners
rad	–	defines the radius of the circle, that draws the rounded corners

Draw arc inside rectangle sub-command

Pixels outside rectangle will be not be drawn.

!disp arcxy c x y rad rx1 ry1 rx2 ry2↵
>

Parameters:

c	–	color 0 → black, 1 → white
x, y	–	arc center coordinate position
rad	–	arc radius
rx1, ry1	–	coordinate of the upper left corner of limiting rectangle
rx2, ry2	–	coordinate of the lower right corner of limiting rectangle